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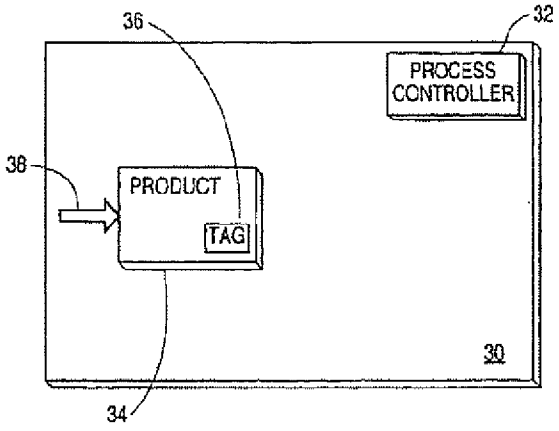
(54) Title: MANAGING PRODUCTION AND OPERATIONS USING READ/WRITE RFID TAGS



(57) Abstract: A method for production and operations management comprises the steps of: associating a read/write RFID tag (36) with a product (34) to be processed; subjecting the product (34) to at least one process; and, writing information to the associated tag (36) relating to the at least one process, whereby application of the at least one process to the product (34) can be confirmed by reading the information from the associated tag (36). The method can further comprise the steps of: subjecting the product (34) to a further process; reading from the associated tag (36) the information relating to the at least one process; modifying the further process in accordance with the read information; and, writing further information to the associated tag (36) related to the further process. The processes (Process1-ProcessN) can include, for example, at least one of a manufacturing process, an inspection process, a shipping process, a warehousing process and a retailing process.

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MANAGING PRODUCTION AND OPERATIONS USING READ/WRITE RFID TAGS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to the field of managing production and operations, and in particular, to a method for establishing and recording a history of a process from manufacture to final sale or other use.

2. Description of Related Art

One of the problems reported in Production and Operations Processes Operation Management is inaccurate data acquisition, both in Manufacturing Processes (MRP systems) and in Operation processes, for example, warehouse management, shipping, distribution, and inventory control and article surveillance at the point of sale.

Another problem is that in traditional Production and Operations processes there is no recorded history of the process or processes concerning a product. The lack of recorded history is due to the absence of communication links or networks between the processes themselves and between the processes and the products that are processed.

In a standard Production and Operations Processes Operation, as illustrated in Figure 6, communication between processes is not possible all the time for a number of reasons. The processes can be distant form one another, for example being implemented in different plants and even different countries. The processes can also be fundamentally different from one another, for example, foundry operation, machining and distribution.

As a consequence, there is no information on the conditions of the processes linked to the product. The information of the conditions can be expressed in terms of efficiency of the processes, duration of the processes and incidents that affect the products. As a more basic consideration, the conditions can also be a determination as to whether a particular process has even been performed or implemented in the first instance.

A standard production and operations processing sequence 10 is shown in Figure 7. A product is shown in four stages denoted by 12A, 12B, 12C and 12D. In processing station 14, the product in stage 12A can, for example, be subjected to one or more manufacturing processes. The form of product in stage 12A can be an automobile in production, a television in production or an article of clothing in production, just to name a few possibilities. In

processing station 16, for example, the product in stage 12B can be inspected for quality assurance. Although the inspection can be thorough, there is no comprehensive and automatic record which can be easily checked to assure that every single manufacturing process to which the product was subjected was, in fact, appropriately applied. In processing station 18, the product in stage 12C is, for example, in transit to a warehouse as part of a distribution channel. Finally, the product leaves the warehouse in stage 12D for retail merchandising at a point of sale. There is a certain measure of paper documentation which can accompany some products, for example the sticker on an automobile or an instruction manual, but in the end, as the product is finally ready to purchased by a consumer, there is no single record of the product's processing history.

Certain limited aspects of this situation have been addressed in part by the KANBAN system developed in Japan. Kanban means "label" in Japanese. In accordance with the system a paper label is associated with a product as manufacturing commences. When the product is sold the label is returned to the manufacturing unit. Production of new products, that is to replace those sold out of inventory, is based on the quantity of labels returned. A related system for tracking work in process (WIP) is continuous work in process tracking (CONWIP), which starts tracking at the end of processing. Neither system can provide information from each product process and neither can provide for electronic or other automatic reading and writing data from and to the label, nor is there any provision for automatically controlling subsequent processes. Finally, neither system provides tracking or control subsequent to the initial processing facility, which can have a plurality of process stations. In both systems, the variable information is effectively discarded at the conclusion of processing in any given processing facility.

There is a long-felt need to automatically establish a recorded history for all of the processes to which a product can be subjected, from initial manufacture to an ultimate retail sale, irrespective of where the processes are implemented, which record can be accessed by appropriate management at any stage of the product's processing history.

SUMMARY OF THE INVENTION

In accordance with the inventive arrangements, a read/write radio frequency identification (RFID) tag is associated with a product. The tag records the conditions of the process and the specific information the process needs to know about the product to perform

the process. At each location representing application of a process, a data store in the tag can be interrogated by appropriate management. Interrogation can be implemented through a computer controlled communications network. Read/write RFID terminals at each processing station provide the basic communications interface between the associated tags and the processing stations.

At the end of each process, the tag is loaded with data that are the history and the proof of the process conditions. In addition the tag/product can interact with a subsequent processing station to modify the process applied by the processing station it accordance with the information stored by a previous processing station. The data stored in the tag can therefore provide information for the next process, for example, distribution, retail sale, return of the product and perpetual inventory after purchase. In addition to all of the foregoing advantages, the tag can also be used as an identifier for an electronic article surveillance system, to prevent shoplifting and pilfering from inventory.

A method for production and operations management, in accordance with an inventive arrangement comprises the steps of: associating a read/write RFID tag with a product to be processed; subjecting said product to at least one process; and, writing information to said associated tag relating to said at least one process, whereby application of said at least one process to said product can be confirmed by reading said information from said associated tag.

The method can further comprise the step of reading from said associated tag said information relating to said at least one process.

The method can also further comprise the steps of: subjecting said product to a further process; reading from said associated tag said information relating to said at least one process; modifying said further process in accordance with said read information; and, writing further information to said associated tag related to said further process.

The at least one process and the further process can be at least one of a manufacturing process, an inspection process, a shipping process, a warehousing process and a retailing process.

A method for managing processing of a product subjected to a succession of product processes, in accordance with a further inventive arrangement, comprises the steps of: associating a read/write RFID tag with said product; and, writing information to said tag related to said product processes.

The step of writing said information to said tag can be implemented upon completion of each said product process.

The method can further comprise the step of reading from said associated tag said information related to said product processes.

The writing step can comprise the steps of: writing information indicative of completing said product processes; and, selectively writing control data for subsequent product processes onto said associated tag.

At least some of said control data can be written prior to said succession of product processes.

One or more of the processes can be modified in accordance with said read information, particularly the control data.

The product processes can include at least one of a manufacturing process, an inspection process, a shipping process, a warehousing process and a retailing process.

A system for processing a product, in accordance with another inventive arrangement, comprises: a read/write RFID tag associated with said product; a plurality of processing stations; a process controller operatively associated with each said processing station; an RFID reader/writer operatively associated with each said processing station for transferring data between said process controller and said associated tag; a tag controller; a first network enabling communications between said tag controller and each said process controller, each said process controller being responsive to control data transmitted by said tag controller and transferred from said associated tag; and, a second network enabling communications between said tag controller and at least one management center controller, whereby processing of said product can be monitored and controlled by said at least one management center at each said processing station, irrespective of the nature and location of the processing stations.

The processes performed at said processing stations can include at least one of a manufacturing process, an inspection process, a shipping process, a warehousing process and a retailing process.

The at least one management center controller can comprise at least one of a manufacturing controller, an inspection controller, a warehouse controller, a shipping controller and a retail point of sale controller.

BRIEF DESCRIPTION OF THE DRAWINGS

Figures 1-3 sequentially illustrate a read/write cycle, in accordance with the inventive arrangements, for an RFID tag associated with a product being processed.

Figure 4 is a diagram of a read/write RFID tag used in accordance with the inventive arrangements.

Figure 5 is a block diagram illustrating a communications and control arrangement in accordance with the inventive arrangements.

Figure 6 illustrates the different communication paths for information in accordance with the inventive arrangements.

Figure 7 is an illustration useful for explaining prior art product processing.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In accordance with the inventive arrangements, a read/write RFID tag is associated with a product during processing. Processing is used broadly herein to denote any change to a product, including but not limited to manufacturing processes, inspection processes, distribution processes, shipping processes, warehousing processes and retail processes. Any change in a product, including but not limited to physical structure, appearance, movement, location, custody and ownership is a process which can be tracked in accordance with the inventive arrangements, by storing information on a read/write RFID tag associated with the product, and by reading the information from the tag and routing the information to various process managers or management structure. Although many different kinds of processes are identified herein as examples, the processes shown in the drawings are deemed to be generic processes for purposes of explaining the inventive arrangements. Similarly, although many different kinds of products are identified herein as examples, the products identified in the drawing are deemed to be generic processes for purposes of explaining the inventive arrangements. Although there are probably some products which by their nature can defy practical association with a read/write RFID tag during processing, as a practical matter, the inventive arrangements are nevertheless deemed to be universally applicable for all products and processes.

The inventive arrangements include a methodology that provides a connection between the processes themselves, using the tags associated with each product as a communication and information storage media. Use of the term product herein generally

refers to one or more products. The tag carries the information concerning all the processes that the product is subjected to. In addition, the information can represent the conditions of the processes and how the processes affect the products.

The read/write RFID tags are associated with each product to be processed. The tag can contains fixed data, for example bar code and SKU identifiers, and variable data that can reflect the evolution of the product through a succession of processes. Variable data can be erased when the information is no longer needed.

Figure 1 shows a processing station 30 having a process controller 32. The processing station subjects a product 34 to a process n, wherein n indicates that the process n can be the first, last or any intermediate processing step in a succession of processes to which the product 34 is subjected. Entry of the product 34 having a read/write RFID tag 36 associated therewith into the processing station 30 is represented by arrow 38. The tag is shown in more detail in Figure 4. As a standard RFID tag, tag 36 comprises a data store 40 and an activated electronic article surveillance element 42. The data store 40 can contain fixed and variable information.

In Figure 2, information from the data store 42 in the tag 36 is communicated to the process controller 32, represented by arrow 46. This information can be used to control or modify the process, or can simply confirm that a prerequisite processing step has been successfully performed. The actual processing to which the product is subjected is represented by arrow 48. The process n can include manufacturing, inspection, distribution, shipping, warehousing and retailing, in accordance with the non-limiting examples noted above. The implementation of process n can result in a change in product structure, appearance, movement, location, custody and ownership, in accordance with the non-limiting examples noted above. The information in the data store can be written during or after completion of a preceding process or even before any processing is undertaken. If the product is an article that can be painted in a variety of colors, for example, the tag can include control data for a paint processing station which specifies the color to be applied to the product. Upon completion of processing, information can be written to the tag confirming that the product was painted with the specified color.

In Figure 3, process n has been completed, and information relating to completion of process n is communicated from the process controller back to the data store 40 in tag 36, represented by arrow 52. The product 34, which can be thought of as having evolved through the implementation of process n, leaves the processing station 30 as indicated by arrow 54.

The information in the tag 36 has been updated to reflect completion of process n, and can include one or more instructions, in the form of control data, for use by subsequent processing stations.

The fixed data concerning the product which can be stored in the tag can include, for example and without limitation, product identification, which can include: name; family; weight; and, size. The variable information concerning the product which can be stored in the tag can include, for example and without limitation: durability date; warranty date and conditions; and, special manufacturing orders. Information provided by the processing stations, concerning the process to which the product was subjected, can include, for example and without limitation: process plan identification; process n identification; type of process; batch number; date of process; duration of the process; waiting time between processes; and, noteworthy process conditions and incidents, for example over-time and over-temperature.

Figure 5 is a block diagram illustrating a communications and control arrangement in accordance with the inventive arrangements. A processing station 30 having a process controller 32 corresponds to that shown in Figures 1-3. A product 34 having a read/write RFID tag 36 associated therewith is being subjected to process n. A radio frequency (RF) reader/writer 66 communicates with the tag 36 by an RF link 68. The read/writer 66 also communicates with a tagging communications backbone 72 through an industrial controller and protocol converter 70. The process controller 32 communicates with the industrial controller and protocol converter 70 by a link 58 which can be an RS232/485 link or a TCP/IP link.

Each industrial controller automatically processes all functions or applications that are required to communicate with the processing stations and the control and management networks. The main characteristics of the industrial controller is to distribute the processes and the databases inside the buildings close to the diversified sensors and the actuators. Sensors can include, for example: smoke detectors, RFID readers, tag readers, access card readers and other sensors associated with the processing stations in which the product is subjected to processing. Actuators can include, for example: conveyors, industrial robots, electric door locks, lights and sirens. Automated functions or applications can include, for example: access control, building management systems, electronic asset surveillance, article sensing and tracking, video switching, audio switching and performance analysis.

Each industrial controller uses a peer to peer communication and can communicate with any other industrial controller without host. Each industrial controller is inter-operable can implement co-processed functions between diversified applications. Each industrial controller is also inter-operable with other system provider's applications, for example: audio, video, access control, building management systems and RFID.

The communications backbone 72 communicates with other industrial controllers and protocol converters 74 and 76, for example by a TCP/IP line 78. The communications backbone 72 enables links between each of the processing and tagging components described above and an intelligent tagging application 80 running on a computer 82.

The intelligent tagging application 80 also communicates with a second communications backbone 84, denoted a corporate backbone. The communications backbone 84 enables communications between the intelligent tagging application 80 and each of, for example, a corporate mainframe computer 86, a manufacturing management computer 88, a warehouse management system computer 90 and other applications 92. The communications backbone 72 forms a first communications network 62 and the second communications backbone 84 forms a second communications network 64.

The two networks 62 and 64 enable information and control data to be transmitted between any components on either of the communications networks. Several communications paths are delineated for purposes of illustration. Information passes between the tag 36 and the process controller 32 by or through components 58, 70, 66 and 68. Information passes between the tag 36 and the intelligent tagging application 80 by or through components 68, 66, 70 and 72. Information passes between the process controller 32 and the intelligent tagging application 80 by or though components 58, 70 and 72. Information passes between the tag 36 and the corporate mainframe 86 by or through components 68, 66, 70, 72, 80 and 84. Information passes between the process controller 32 and the manufacturing management computer 88 by or through components 58, 70, 72, 80 and 84.

Figure 6 illustrates process to process communications, process to product communications and product to process communications in a global processing operation 100. Implementation of these communications can be accomplished by the communications and control network 60 illustrated in Figure 5. Global processing operation 100 comprises a processing station 102 for implementing process 1, a processing station 104 for implementing process 2 and a processing station 106 for implementing processes n. As a practical matter,

most global processing operations will comprises tens or hundreds or even thousands of processing stations. Moreover, as explained in connection with Figures 1-3, the processing stations can be scattered across the planet, and can be the virtually any process, from and including manufacture to retail sale, and even beyond, insofar as product warranty processes subsequent to sale can be encountered. In Figure 6, a product in a form 110A is subjected to process 1 in processing station 102. Information from the product, that is the RFID tag 36, is communicated from the tag 36 to process 2, as illustrated by arrow 112. This information can include, for example, batch number, lot number and size of the lot. The product in a form 110B is subjected to process 2 in processing station 104. Information is communicated from process 2 to the product, that is the tag 36, as illustrated by arrow 114. This information can include, for example: product identification, which can include name, family, weight and size; durability; warranty date and conditions; and, conditions of manufacturing, handling, shipping history (date, duration) and storage history (date, duration). Information is communicated from the product, that is the tag, to process n as illustrated by arrow 116. This information can include, for example: product identification, which can include name, family, weight and size; durability; warranty date and conditions; and, conditions of manufacturing, handling, shipping history (date, duration) and storage history (date, duration). The product in a form 110C is subjected to process 106. Eventually the product is complete in a form 110D. In each processing stations, the various kinds of communication described above can take place. Moreover, thought the global processing operation 100 the various processes can be monitored by appropriate management applications and control data can be supplied to the processing stations from the appropriate management applications.

The inventive arrangements provide numerous benefits in the areas of performance, real time process control and quality. The standard productions systems (command and control) determine if a task is achieved. However, the real aim should be to verify and prove at any time that the process is in a correct evolution, and if the objective performance is close to the expected or perceived performance. In other words, in accordance with the inventive arrangements, the difference can be determined between the actual performance and the programmed or forecasted performance or the effective utilization ratio in a warehouse. The difference is counted and recorded to determine in real time the performance ratio. This ratio is the inverse of the deficiency gap, or the lack of performance.

The inventive arrangements can provide a view in real time of the entire process because the monitoring network knows where the products are and what their actual status is as works in process. The perpetual inventory can be more accurate because the information concerning the products that are works in process can be integrated with the inventory of the finished products. All products will be appraised at the right cost.

The feedback enables real-time production decisions and plan changes, increases the visibility of problem situations, and provides a better prediction of production levels. A synchronization can be achieved between the processes and the management control which integrates the production and operations system, including manufacturing, logistics and distribution operations.

Quality of the product with respect to manufacturing quality standards can be continuously monitored throughout production and many other kinds of processing, and always be available.

What is claimed is:

1. A method for production and operations management, comprising the steps of:

associating a read/write RFID tag with a product to be processed;

subjecting said product to at least one process; and,

writing information to said associated tag relating to said at least one process,

whereby application of said at least one process to said product can be confirmed by reading said information from said associated tag.

2. The method of claim 1, further comprising the step of: reading from said associated tag said information relating to said at least one process.

3. The method of claim 1, further comprising the steps of:

subjecting said product to a further process;

reading from said associated tag said information relating to said at least one process;

modifying said further process in accordance with said read information; and,

writing further information to said associated tag related to said further process.

4. The method of claim 1, wherein said at least one process is at least one of a manufacturing process, an inspection process, a shipping process, a warehousing process and a retailing process.

5. The method of claim 3, wherein said at least one process and said further process include at least one of a manufacturing process, an inspection process, a shipping process, a warehousing process and a retailing process.

6. A method for managing processing of a product subjected to a succession of product processes, comprising the steps of:

associating a read/write RFID tag with said product; and,

writing information to said tag related to said product processes.

7. The method of claim 6, comprising the step of writing said information to said tag upon completion of each said product process.

8. The method of claim 6, further comprising the step of:

reading from said associated tag said information related to said product processes.

9. The method of claim 6, wherein said writing step comprises the step of writing information indicative of completing said product processes.

10. The method of claim 6, wherein said writing step comprises the step of selectively writing control data for subsequent product processes onto said associated tag.

11. The method of claim 6, wherein said writing step comprises the steps of:

writing information indicative of completing said product processes; and,

selectively writing control data for subsequent product processes onto said associated tag.

12. The method of claim 11, comprising the step of writing at least some of said control data prior to said succession of product processes.

13. The method of claim 8, further comprising the step of:

modifying one of said product processes in accordance with said read information.

14. The method of claim 11, further comprising the step of:

modifying at least one of said product processes in accordance with said control data.

15. The method of claim 12, further comprising the step of:

modifying at least one of said product processes in accordance with said control data.

16. The method of claim 6, wherein said product processes include at least one of a manufacturing process, an inspection process, a shipping process, a warehousing process and a retailing process.

17. The method of claim 12, wherein said product processes include at least one of a manufacturing process, an inspection process, a shipping process, a warehousing process and a retailing process.

18. The method of claim 15, wherein said product processes include at least one of a manufacturing process, an inspection process, a shipping process, a warehousing process and a retailing process.

19. A system for processing a product, comprising:

a read/write RFID tag associated with said product;

a plurality of processing stations;

a process controller operatively associated with each said processing station;

an RFID reader/writer operatively associated with each said processing station for transferring data between said process controller and said associated tag;

a tag controller;

a first network enabling communications between said tag controller and each said process controller, each said process controller being responsive to control data transmitted by said tag controller and transferred from said associated tag; and,

a second network enabling communications between said tag controller and at least one management center controller,

whereby processing of said product can be monitored and controlled by said at least one management center at each said processing station, irrespective of the nature and location of the processing stations.

20. The system of claim 19, wherein processes performed at said processing stations include at least one of a manufacturing process, an inspection process, a shipping process, a warehousing process and a retailing process.

21. The system of claim 20, wherein said at least one management center controller comprises at least one of a manufacturing controller, an inspection controller, a warehouse controller, a shipping controller and a retail point of sale controller.

22. The system of claim 19, wherein said at least one management center controller comprises at least one of a manufacturing controller, an inspection controller, a warehouse controller, a shipping controller and a retail point of sale controller.

FIG. 1

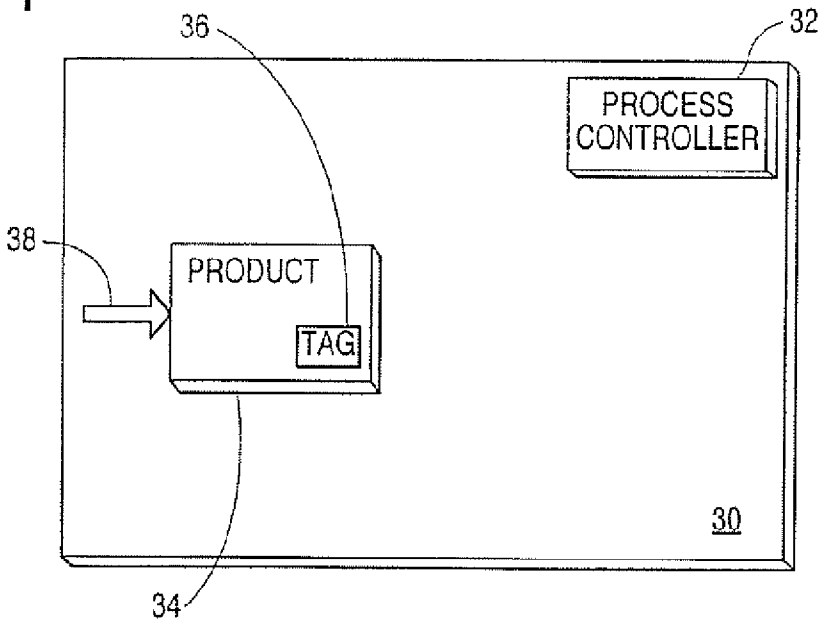

36
32
PROCESS CONTROLLER
38
PRODUCT
TAG
30
34

FIG. 2

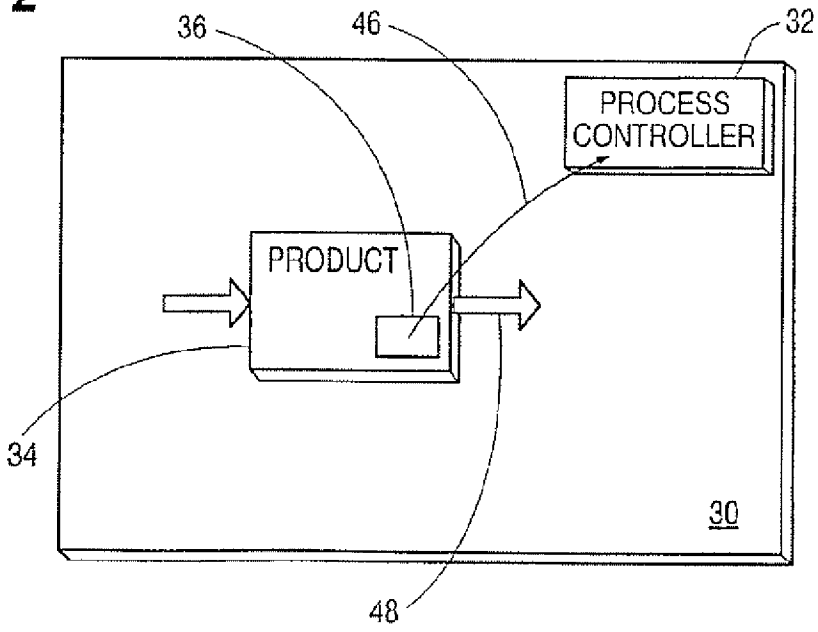

36
46
32
PROCESS CONTROLLER
PRODUCT
34
30
48

FIG. 3

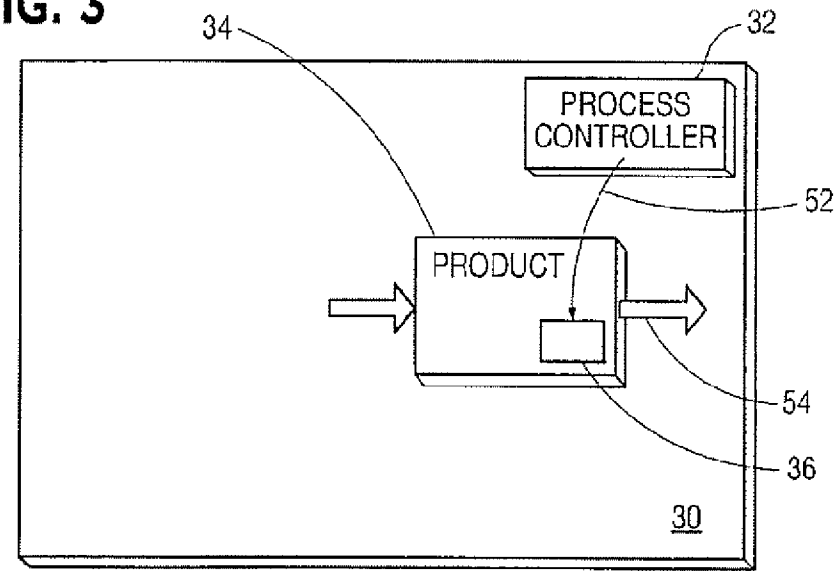


FIG. 4

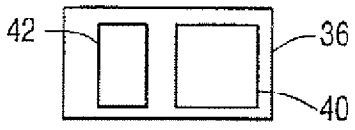
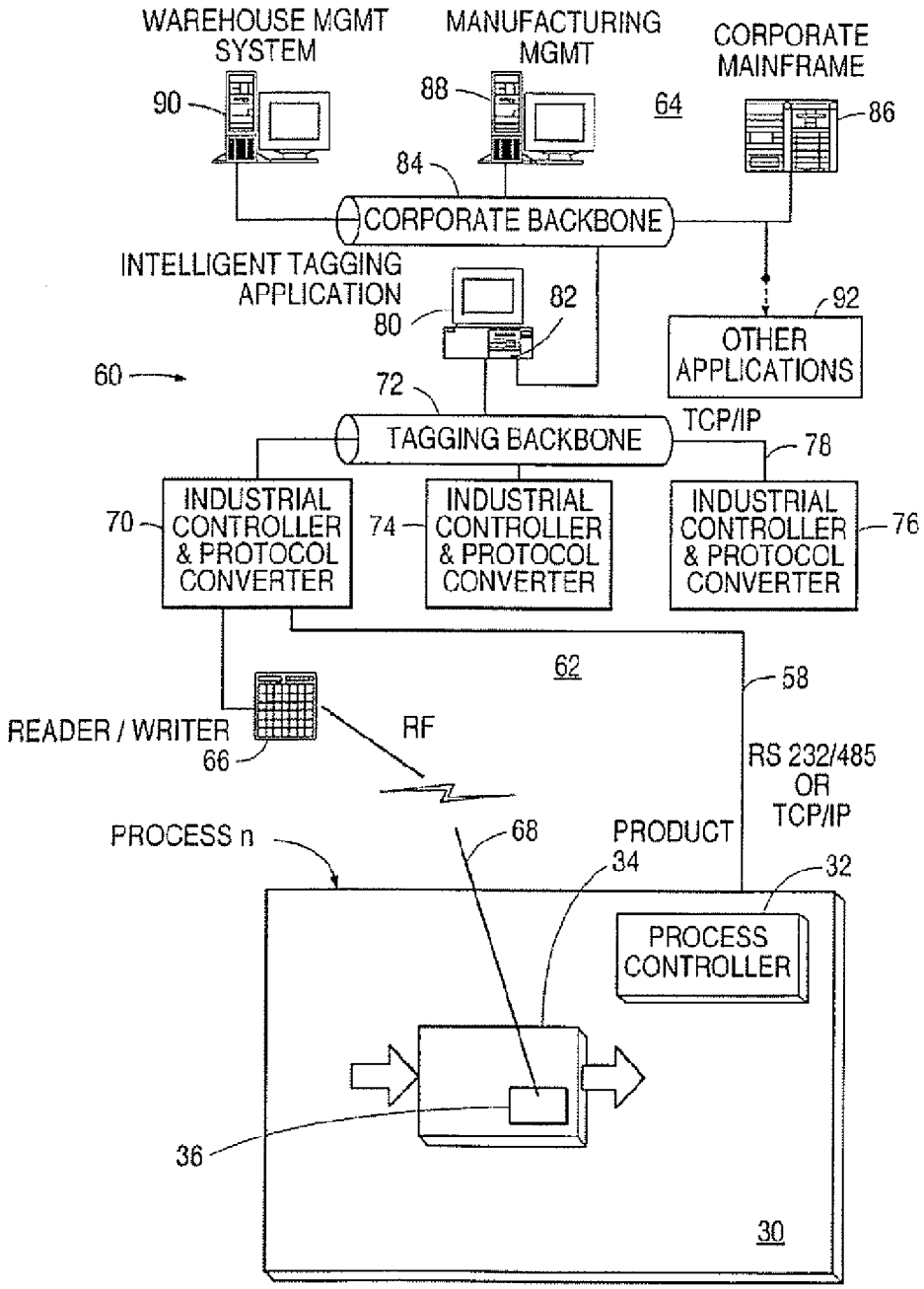


FIG. 5


WAREHOUSE MGMT SYSTEM
MANUFACTURING MGMT
CORPORATE MAINFRAME
90
88
64
86
84
CORPORATE BACKBONE
INTELLIGENT TAGGING APPLICATION
80
82
92
OTHER APPLICATIONS
60
72
TAGGING BACKBONE
TCP/IP
78
INDUSTRIAL CONTROLLER & PROTOCOL CONVERTER
70
74
76
62
58
READER / WRITER
66
RF
RS 232/485 OR TCP/IP
PROCESS n
68
PRODUCT
34
32
PROCESS CONTROLLER
36
30

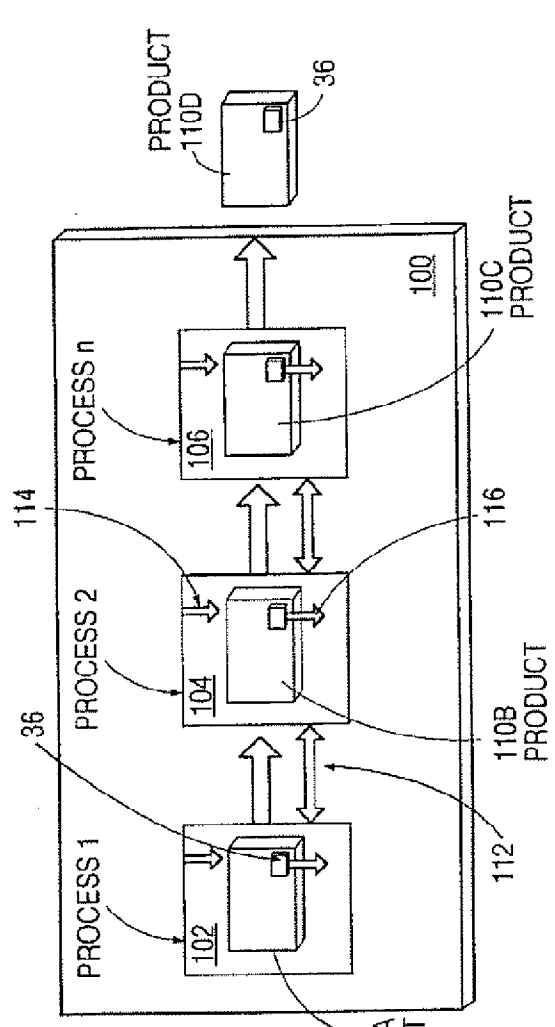


FIG. 6

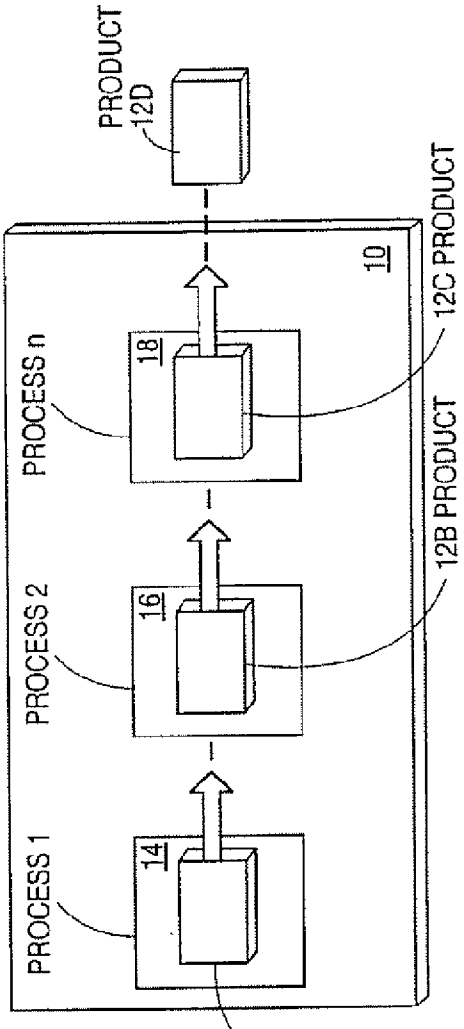


FIG. 7
(PRIOR ART)